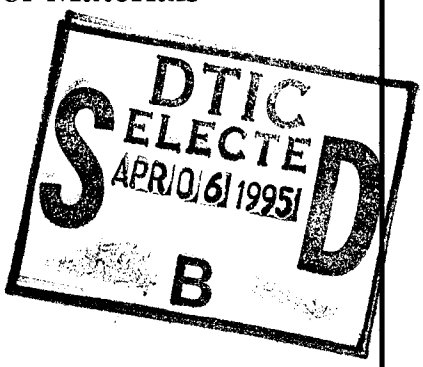
AOARD REPORT

Tenth International Conference on the Strength of Materials (ICSMA 10), Sendai, Japan, 21-26 Aug 94



21-26 Aug 94
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The ICSMA 10 conference provided an excellent snapshot of our current understanding of the fundamental mechanisms of the deformation and failure of crystalline materials. One of the more provocative papers was presented by Prof Vitek who presented a model linking brittle intergranular fracture caused by the structure of segregated grain boundaries in alloys, and the grain boundary structures in intermetallics. Several interesting papers of an empirical nature were also presented, including reviews of nano-laminated materials, high strength, ductility and stiffness quasicrystalline Al-based alloys, and a comprehensive review of superplastically formable fine-grained ceramics.

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2. OVERVIEW AND BACKGROUND

The ICSMA conference series has established itself as one of the premier conferences dealing with the fundamental issues of strength, plasticity, and deformation of crystalline materials. The first conference in the series was held in Tokyo in 1967, and subsequent conferences have been held approximately every three years in other locations throughout the world. The prime sponsor of ICSMA 10 was the Japan Institute of Metals, which also sponsored the first conference in Tokyo. The host and head organizer of the conference was the laboratory of Professor Hiroshi Oikawa, of Tohoku University, Sendai (see TR-94-13).

The conference took place over 4 1/2 days, with several keynote lectures each morning, followed by five concurrent sessions throughout the remainder of the day. There were 11 conference session topics: Dislocations and Other Defects; Plastic Deformation; Strength of Materials; Fracture and Toughness; Fatigue; Creep; Creep Strength of Materials; High Temperature Deformation; Strength of Small Scale Materials; Interface Related Phenomena; and Environmental Effects. Two of the session topics, Strength of Small Scale Materials and Interface Related Phenomena were added to the conference for the first time, although the contributed papers in those two sessions were small in number. In total, 235 papers are published in the proceedings, with a slightly smaller number of papers presented at the conference, due to cancellations.

Approximately 240 people attended the conference, evidently a substantial decrease from previous years. Several possible reasons for declining attendance were discussed, ranging from a sluggish world-wide economy, the strong Japanese yen, and other competing conferences with similar objectives and themes. The demographics of the 240 participants were as follows: Japan - 118; Europe (including the FSU) - 81; USA - 13; Other Asia - 16; Other - 15. It is interesting to note the low US attendance, especially compared to the strong European participation. The site of ICSMA 11 in Aug of 1997 will be Prague, Czechoslovakia.

3. CONFERENCE HIGHLIGHTS

The quality of the majority of the papers was excellent. However, only several of the keynote and contributed presentations will be mentioned here. Below are listed the title, primary author and affiliation, and a short synopsis of several of the highlights. In the area of mechanisms and models:

"Interaction of High Cycle Fatigue with High Temperature Creep," P. Lukas, et al, Institute of Physics of Materials, Academy of Sciences of the Czech Republic, Brno, Czech Republic. The author reviewed studies on the interaction of high cycle fatigue and creep in several model systems (copper, nickel) and several steel alloys, and discussed structural and microstructural changes caused by cycling. A proposed mechanism of damage evolution and failure under these conditions was presented, utilizing the composite model of dislocation structure.

"Influence of Dislocation Fine Structure on the Strength and Flow Behavior of Ordered Intermetallic Compounds," M. J. Mills, et al, Sandia National Laboratory, Livermore, CA. The authors reviewed the seemingly disparate strength and flow behavior of Ni_3Al and NiAl, in light of their superlattice and operative dislocation structures. In particular, the dislocation decomposition in these alloys which often lead to non-planar configurations with sessile components were discussed.

"High-Temperature Deformation Mechanism in Solution-Hardened Alloys," Hideo Yoshinaga, et al, Kyushu University, Kasuga, Japan. The solute-atmosphere drag

mechanism was discussed and applied to Mg solution strengthened Al alloys undergoing high temperature deformation. The model provided a reasonably quantitative description of the observed behavior when incorporated with recent observations regarding dislocation density and mobility in this alloy system.

"Atomic Structure of Grain Boundaries and its Relation to Intergranular Fracture," Vaclav Vitek, University of Pennsylvania, Philadelphia, PA. This excellent paper discusses the important role of grain boundary structure and chemistry in the fracture of alloys and intermetallics. It is argued that the segregation process in the grain boundaries of alloys leads not to a random filling of available atomic sites by the segregates, but may involve the formation of new, small grain boundary phases. These two dimensional grain boundary phases are proposed to be the key to the understanding of intergranular brittleness in both disordered alloys, and ordered intermetallic compounds, requiring further investigation.

There were several other papers which presented more empirical work, which have been selected because of their potential importance. The format is the same as above.

"Superplastic Flow in Fine-Grained Ceramics," Taketo Sakuma, University of Tokyo, Tokyo, Japan. The importance of grain size stability and the presence and morphology of glassy grain boundary phases on the superplastic behavior of ceramics was reviewed in detail. Data and observations were presented and reviewed for various ceramic systems based on TZP, Al_2O_3, Si_3N_4, Beta-SIALON, with various dopants and reinforcements. Superplastic elongations in excess of 100% (as high as 1000% is some systems) in all of these systems have been reported. In nearly all of the systems, the superplastic behavior is optimized in the temperature range of 1350-1450°C. Although the paper is short on elegant models, it presents detailed empirical observations in this potentially important new area of ceramic processing.

"Mechanical Properties of Cu-Ni Super-Laminates Fabricated by Rolling," Shiomi Kikuchi, et al, Kyoto University, Kyoto, Japan. A unique rolling fabrication process for micro- and nano-laminated Cu-Ni was presented and discussed. A tensile strength in excess of 1300 MPa was reported for a nano-laminated Cu-Ni structure with a layer thickness of 12 nm. The effect of aging and annealing on the chemical, structural, and tensile behavior of these structures was also presented.

"High Strength Quasicrystalline Alloys," Akihisa Inoue, et al, Institute for Materials Research, Tohoku University, Sendai, Japan. This paper provided a review and update on the progress of high-strength quasicrystalline Al-Mn-Ce and Al-Cr-Ce-Co alloys. The alloy compositions have been optimized to be Al rich, which dramatically improves the tensile ductility at room temperature. This effect is believed to be caused by the increase of Al-Al atomic pairs, and the formation of a continuous, or near continuous high density crystalline phase. One mixed phase alloy (Al-3Cr-1Ce-1.5Co) exhibits good ductility and a tensile strength of 1340 MPa. In addition to the high strength, and relatively high ductility when compared to other high strength or high temperature Al alloys, the modulus of these alloys is approximately 1.5 times that of normal Al alloys. Bulk alloys have also been produced through extrusion, and retain strengths in excess of 500 MPa, RT elongations of approximately 20%, and retain in excess of 250 MPa strength at 400°C. Toughness studies are still underway.

4. SUMMARY AND COMMENTS

The ICSMA conference series continues to be one of the premier conferences on the fundamentals of deformation and failure in crystalline materials, as it continues to attract an impressive body of researchers and papers.

In the opinion of the author, one of the best keynote lectures was saved for last, presented by Prof Vitek of the University of Pennsylvania. He presented a model linking brittle intergranular fracture caused by the structure of segregated grain boundaries in alloys, and the grain boundary structures in intermetallics. This proposal, if confirmed by atomistic studies and experiments may lead to dramatic improvements in future alloys.

Several interesting papers of an empirical nature were also presented, including reviews of nano-laminated materials, high strength, ductility and stiffness quasicrystalline Al-based alloys, and a comprehensive review of superplastically formable fine-grained ceramics. In particular, the quasicrystalline Al alloy work appears ripe for commercialization, with a very attractive combination of high strength and stiffness Al alloys, with good ductility. The alloy systems may also offer possibilities as new high temperature Al alloys, although chemical and structural stability needs to be studied further.